

REMARKS

The specification has been amended in several places to correct typographical and grammatical errors. No new matter has been added.

5 The undersigned notes with appreciation that Claims 3, 8-10, 12, 16 and 19 were objected to for being dependent on rejected base claims, but were otherwise considered allowable.

The Office Action incorrectly states that claim 19 is dependent on a rejected base claim. Claim 19 is an independent claim, and so should be allowable.

10 Claims 4, 11, 13, 14, and 17 were withdrawn from consideration.

Claim 14 was amended to indicate that the 0.5 lower bound is not necessarily precise to two decimal places.

Claims 20, 21, and 22 have been added, and a check is attached to satisfy the fee for two additional dependent claims. Claims 20-22 are supported by Fig. 7, and text at
15 page 6, line 22 through page 7, line 2. Claims 20-22 require a voltage detector for detecting voltage from the piezoelectric layer. Claims 20-22 thereby more clearly set forth the operation as a magnetic field sensor. Iwasaki et al. does not teach or suggest a voltage detector operable for detecting voltage created by the piezoelectric layer. Iwasaki et al. cannot have a detector detecting voltage from the piezoelectric layer because
20 Iwasaki et al. teach that voltage is applied to the piezoelectric layer to produce strain therein. In Iwasaki et al. the piezoelectric layer does not produce a voltage.

Claims 1-2, 5-7, 15 and 18 were rejected under 35 USC 103(a) as being unpatentable over US Patent 6,387,476 to Iwasaki et al. This rejection is traversed.

The present invention provides a magnetic field sensor having exceptionally high
25 sensitivity. The high sensitivity is a result of the shape of the magnetic field sensor, which has a longitudinal/transverse (L/T) ratio greater than 1, in combination with a longitudinal bias magnetic field. The combination of the nonunity L/T aspect ratio and longitudinal bias magnetic field results in unexpected and extremely high magnetic field sensitivity. These aspects of the present invention are described throughout the
30 specification, in particular at page 4, lines 6-14, and page 7, lines 3-10, for example.

It is important to note that the present invention is a magnetic field sensor. In other words, the present device responds to and detects changes in external applied magnetic field. In the present invention, in order for the device to be a magnetic field sensor, it is essential for the device to convert magnetic field energy into electrical energy (i.e. a voltage applied to the differential amplifier 34).

Iwasaki et al. teach a magnetic functional element that is different from the present invention in several important ways.

Firstly, the device of Iwasaki et al. is not a magnetic field sensor and cannot be used as a magnetic field sensor. The device of Iwasaki et al. is voltage driven, not magnetic field driven as required in the present invention. The device of Iwasaki et al. converts electrical energy into magnetic field energy, which is the opposite of the present magnetic field sensor, and magnetic field sensors generally.

Iwasaki et al. teach a device in which voltage is applied to a strain applying layer 3 12 (i.e. piezoelectric or electrostrictive layer) so that strain is induced in the strain sensitive magnetic layer 2 13 (i.e. magnetostrictive layer). Hence, the device creates a magnetic field or new magnetic state within the strain sensitive layer when voltage is applied. This is clearly explained at col. 7, lines 14-17, col. 7, lines 48-51, col. 8, lines 4-10, and col. 8, lines 37-40. The strain in the strain sensitive layer produces a new magnetic state in the strain sensitive layer, which can be used as the basis for a memory device or other devices (see col. 12, lines 53-59). Iwasaki et al. teach at col. 8, lines 57-59 that it is required for the strain sensitive layer to “change its magnetic state when strain is applied thereto.” This requirement prevents the Iwasaki et al. device from operating as a magnetic field sensor as required in the present claims. This is because in the magnetic field sensor of the present invention, strain is not applied to the magnetostrictive layer (comparable to the strain sensitive layer). Instead, in the present invention, the magnetostrictive layer produces strain and the strain is applied to the piezoelectric layer. The operation of the device of Iwasaki et al. is exactly the opposite of the operation of magnetic sensor of the present invention, and operation of magnetic field sensors generally. Iwasaki et al. is mainly directed toward magnetic memory circuits. Furthermore, Iwasaki et al. does not teach or suggest in any way that the device can

operate as a magnetic sensor (e.g. col. 12, lines 54-67 does not suggest any kind of magnetic field sensing device).

There is no suggestion in the teachings of Iwasaki et al. that the device of Iwasaki et al. could be used as a magnetic field sensor.

5 For this reason, Iwasaki et al. does not render claims 1 or 15 obvious and the rejections of these claims should be withdrawn.

Secondly, the device of Iwasaki et al. does not employ a bias magnetic field, and does not teach or suggest a bias magnetic field oriented in a longitudinal direction.

10 The Office Action erroneously states that a bias field is indicated in Fig. 2A of Iwasaki et al. Fig. 2A shows an unlabeled arrow in the strain sensitive magnetic layer (i.e. magnetostrictive layer); the arrow presumably indicates the internal magnetic state of the strain sensitive magnetic layer. Fig. 2B shows the arrow turned 90 degrees as a result of strain applied by the piezoelectric layer 13. The internal magnetic state of the magnetostrictive layer 13 is not a bias field as required by the present invention. The bias
15 field of the present invention is an externally generated field, for example produced by a permanent magnet or electromagnet. The bias field of the present invention is not the internal magnetic state of the magnetostrictive layer. The bias field of the present invention and internal magnetic state of the magnetostrictive layer are separate and distinct, as is well known and understood to those of ordinary skill in the art.

20 In fact, in many applications contemplated by Iwasaki et al., a bias magnetic field cannot be used because the Iwasaki et al. device is used for magnetic memory applications. A bias magnetic field may prevent the magnetostrictive layer from changing state, which is necessary for the Iwasaki et al. device to operate as a programmable magnetic memory device.

25 The Office Action argues that Figs. 4A-4C teach a bias magnetic field of 100 Oe applied to the Iwasaki et al. device. This is incorrect and misleading. Figs. 4A-4C (and Figs. 5A-5D) illustrate magnetic hysteresis curves under different strain conditions and external magnetic field conditions for a magnetic thin film 21 tested with the apparatus of Fig. 3 (the external magnetic field is produced by coils 22). The experiments are
30 described in columns 9, 19, 11, and 12. It is important to note that the apparatus of Fig. 3 (including external field generated by coils 22) was used for testing the magnetic

properties of the magnetic thin film so that appropriate materials could be identified. Specifically, Iwasaki et al. prefers a magnetic material with a magnetic anisotropy highly dependent on strain (see col. 11, lines 65-67, and col. 12, lines 7-13). Figs. 3 and 4A-4C and the corresponding discussion merely describe how to identify such a material. Figs. 3
5 and 4A-4C and the corresponding discussion does not teach or suggest the use of a longitudinal bias magnetic field in the present magnetic field sensor or the use of a longitudinal bias magnetic field in the device of Iwasaki et al. The apparatus of Fig. 3 and coils 22 are not used in combination with the devices of Iwasaki et al.

The Office Action argues that, in the absence of criticality, the dimensions of the
10 magnetic field sensor are a matter of design choice. However, the present inventors have unexpectedly discovered that magnetic field sensors with L/T ratio greater than 1 or 1.2 or 1.5 have surprisingly high sensitivity, particularly when a longitudinal (i.e. parallel with the long dimension) magnetic field is employed. While various sizes of the layers can be employed, and one of ordinary skill in the art may attempt various sizes, there is
15 no particular motivation or expected benefit from making the device longer in the direction of the applied bias field, as required in claims 1 and 19. The sensitivity improvements provided by this particular combination of magnetic field orientation and device shape are significant, unexpected and would not be obvious to one of ordinary skill in the art.

20 Regarding claim 15, Iwasaki et al. does not teach or suggest or render obvious the claimed thickness ratio limitation in a magnetic field sensor. Iwasaki et al. in fact is silent with regard to thickness ratios between the piezoelectric and magnetostrictive layers. Iwasaki et al. provides no motivation or expectation of higher sensitivity or other benefits from adjusting the thickness ratio of the layers in a magnetic field sensor. Accordingly,
25 the rejection of claim 15 is erroneous for this additional reason and should be withdrawn.

Claims 4, 11, 13, 14, and 17 were withdrawn as being drawn to non-elected species; they should now be considered and be allowed, as they depend from allowable claims 1 and 15. Consideration and allowance of these claims is respectfully requested.

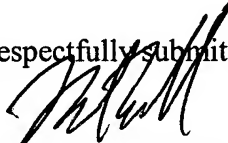
In view of the foregoing, it is respectfully requested that the application be
30 reconsidered, that claims 1-22 be allowed, and that the application be passed to issue.

Should the Examiner find the application to be other than in condition for allowance, the Examiner is requested to contact the undersigned at the local telephone number listed below to discuss any other changes deemed necessary in a telephonic or personal interview.

5 A provisional petition is hereby made for any extension of time necessary for the continued pendency during the life of this application. Please charge any fees for such provisional petition and any deficiencies in fees and credit any overpayment of fees for the petition or for entry of this amendment to Attorney's Deposit Account No. 50-2041 (Whitham, Curtis & Christofferson P.C.).

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Respectfully submitted,



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